PHYTOTOXICOLOGY SURVEY REPORT RE-ASSESSMENT OF THE LESLIE STREET ALLOTMENT GARDEN, TORONTO (1992)

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TORONTO (1992)

Report prepared by:

S. Bisessar
Phytotoxicology Section
Standards Development Branch

Abstract

Phytotoxicology Survey Report: Re-assessment of the Leslie Street Allotment Garden - Toronto (1992).

In June 1992, the Phytotoxicology Section sampled soil from 8 garden plots at the Leslie Street Allotment Garden. All the soil samples were analyzed for 10 inorganic elements, mostly metals, and two sites were analyzed for dioxins and furans. The results were compared with earlier sampling conducted in 1988. The 1992 data suggests that the adjacent metro works incinerator ash piles have not had a measurable adverse impact on soil quality. There has been no significant change in soil inorganic or organic concentrations relative to the first (1988) sampling. Although soil dioxin concentrations were marginally higher at the sample site closest to the ash piles, the concentrations at both sites were within the range normally encountered in urban soil.

Phytotoxicology Survey Report: Reassessment of the Leslie Street Allotment Garden -Toronto (1992).

1. Background

On February 9, 1992, the Ministry of Environment and Energy Central Region Toronto East Office, requested the Phytotoxicology Section conduct a soil reassessment of the Leslie Street Allotment Garden (LSAG) in Toronto. The LSAG is located on the east side of Leslie Street between Commissioners Street and Unwin Avenue, Toronto. The location of the garden in relation to the incinerator ash piles is shown in the attached sketch map. In 1988, the Metro Works Department relocated about 54,000 cubic meters of incinerator ash from their collection lagoons to an area immediately east of the LSAG. A previous investigation of the LSAG soil conducted by the Phytotoxicology Section in 1988 detected marginal soil contamination with cadmium and dioxin, although this did not restrict the use of the soil for vegetable gardens[7]. The main reason for this investigation was to provide additional information regarding the possibility that the LSAG has been adversely affected by wind blown ash, leaching from the ash piles, or the lateral movement of ash by water erosion. Also, growers have expressed concerns regarding the trace element content of produce from the garden.

2. Investigative Procedures

On June 1, 1992 soil samples were collected from the six previously sampled garden plots (Sites 54, 69, 151, 194, 203 and 243). Also, soil samples were collected from two additional sites (2 and 9). Site 194 is closest to the ash piles and Site 203 is farthest from the ash piles. A site is defined as all samples collected within a 8.5 X 3.3 m square area, which is the average size of a garden plot. The total area of the garden measured 186 meters from north to south x 60 meters from east to west.

2.2. SAMPLES FOR INORGANIC ANALYSIS

A standard soil sampling procedure was used to collect the soil for inorganic analysis.[6] Samples were collected in duplicate to a depth of 15 cm from 8 sites, which were identified as garden plot numbers 2, 9, 54, 69, 151, 194, 203 and 243 in this report as follows:

Site 2 - adjacent to a mature Linden tree, northeast corner.

Site 9 - northwest corner, about 5 m from north fence and 20 m from west fence.

Site 54 - about 48 m from the north fence, and about 34 m from the east fence.

Site 69 - about 54 m from the north fence, and 31 m from the east fence.

Site 151 - about 117 m from the north fence, and 30 m from the east fence.

Site 194 - southeast corner, about 110 m from the north fence and 10 m from the east fence.

Site 203 - western edge, and about 151 m from the north fence.

Site 243 - about 139 m from the north fence and 15 m from the east fence.

All soil samples for inorganic analysis were processed in the Phytotoxicology Laboratory using standard Phytotoxicology laboratory techniques.[4] These were submitted to the Laboratory Services Branch, MOEE, for analysis of the elements listed in Table 1, on a dry weight basis using standard MOEE analytical techniques.[5,8,10] The pH and electrical conductivity (EC) of the soils were determined in the Phytotoxicology Laboratory.

2. 3. SAMPLES FOR ORGANIC ANALYSIS

Two additional soil samples were collected for organic analysis from Sites 194 and 203. The sampling procedure for organic analysis included cleaning of the sampling equipment between each site using detergent, alcohol and hexane to ensure that no cross-sample contamination occurred.[6] These samples were analyzed for dioxins (PCDD) and furans (PCDF). The samples for organic analysis were placed directly in labelled, wide-mouth, amber-coloured glass jars, which had been solvent rinsed. The foil-lined jar lid was secured with tape when sample collection was completed. All filled jars were placed in an insulated, light-tight cooler until delivery to the MOEE, Organic Trace Contaminants Laboratory for organic analysis, using standard analytical techniques.[11]

3. Results and Discussion

3. 1. SOIL pH AND EC

The LSAG soil was characterized as a silt loam, and it was dark in colour with about 5% organic matter. The EC, which is a measure of total salts, ranged from 0.25 to 0.47 millisiemens/cm. This is a normal soil EC range. Soil pH ranged from 7.2 to 7.5. This is a normal pH range for the soil type.

3. 2. INORGANIC

The inorganic analytical results of the soil and the corresponding Phytotoxicology Section "Upper Limit of Normal" (ULN) guidelines for urban surface soils in Ontario [9] are shown in Tables 1a and 1b. The results are expressed in ug/g (micrograms per gram, commonly referred to as parts per million) and refer to the weight of chemical component per one gram of air-dried soil on a dry weight basis. The derivation and significance of the ULNs are explained in the appendix. These guidelines serve as concentrations, which if exceeded, would suggest a potential source of contamination and may prompt further investigation to determine the source and significance. None of the concentrations at any of the eight sites exceeded the ULN guidelines. None of the 10 elements displayed any evidence of a concentration gradient with distance or direction from the ash piles. All concentrations were well within the range commonly encountered in an urban environment.

The 1992 (and for comparison the original 1988) soil results are summarized in Tables 1a and 1b. The 1992 and 1988 inorganic chemical data from common collection sites are (generally) very comparable. The analytical methodology has been refined since 1988 (better resolution at lower concentrations) so that

some of the 1992 data have "T" qualifiers that identify trace concentrations. The lead concentration at Site 194, which is closest to the ash pile, has increased from 69 ug/g in 1988 to 145 ug/g in 1992. However, the lead concentration has decreased by about the same magnitude at Site 203, which is closest to Leslie Street (120 ug/g in 1988 to 63 ug/g in 1992). Soil lead concentrations have not increased, in fact most have decreased marginally, at the other sampled garden plots. Similarly, soil cadmium concentrations have decreased substantially at Site 194 (from 3.5 ug/g in 1988 to 0.7 ug/g in 1992). Soil cadmium concentrations were (relatively) unchanged at the other garden plots.

3. 3. ORGANIC

Dioxins and furans are chemicals that occur as by products of many industrial and combustion processes. The term dioxin refers to a group of 75 related chemicals, while furans refers to 135 related chemicals. The two groups have similar structures and effects. The most toxic dioxin is 2,3,7,8-tetrachlorodibenzo-p-dioxin or, 2,3,7,8-TCDD. In this study, the total concentrations of 5 dioxin and furan congener groups were obtained. The groups were tetraCDD (T_4CDD, i.e., a group of dioxins that contain 4 chlorine atoms), pentaCDD (P_5CDD, containing 5 chlorine atoms), hexaCDD (H_6CDD, 6 chlorine atoms), heptaCDD (H_7CDD, 7 chlorine atoms) and octaCDD (O_8CDD, a group containing 8 chlorine atoms). As with dioxins, the total concentrations of 5 furan congener groups were determined. These congener groups were T_4CDF, P_5CDF, H_6CDF, H_7CDF and O_8CDF.

Table 2 summarizes the results of the PCDD and PCDF analyses of the soil samples collected in June 1992, and for comparison purposes November 1988. The data are pg/g (picograms per gram, more commonly referred to as parts per trillion). The 1992 results showed that dioxins from four of the five congener groups were detected in soil at two sites (Site 194 - closest to the ash piles, and Site 203 - farthest from the piles). T_4CDD was not detected (detection limit of 2 pg/g) in soil from either site. Dioxin concentrations in 1992 were higher at site closest to the ash piles (4,295 pg/g total dioxin at Site 194 vs 370 pg/g total dioxin at Site 203). Total dioxin concentrations tended to be marginally higher at Site 194 in 1992 and lower at Site 203, relative to 1988.

Furan analysis of soil at Site 194 closest to the ash piles detected concentrations of 52 pg/g T_4CDF, while no T_4CDF was detected (detection limit 2 pg/g) in soil sampled from Site 203, farthest from the ash piles. The highest furan concentration (H_7CDF, 140 pg/g) was detected close to the ash piles, compared to a concentration of 18 pg/g H_7CDF farthest from the ash piles. The furan and dioxin contamination patterns were similar, although the furan concentrations were consistently much lower. For both contaminants, the concentrations were higher at the site closest to the ash piles (Site 194), and (for both contaminants) the concentrations were higher in 1992 close to the ash piles, relative to 1988, and lower in 1992 at the more distant Site (Site 203) than they were in 1988. Experience with sampling soil for dioxin has shown highly variable concentrations. The differences found between years at the LSAG is within the range in variability, and the data shown in Table 2 are (in reality) very similar in concentration.

The Phytotoxicology Section soil dioxin data studies indicate that dioxins from one or more of the five congener groups are found in about 9 out of every 10 urban residential soil samples and about 6 out of every 10 rural soil samples. Furans are less widespread, having been detected in about 25% of Ontario soil samples. Soil dioxin and furan concentrations similar to those found in the LSAG have been detected in Ontario urban residential soil.[12]

The Centre for Disease Control in Atlanta Georgia, USA, has developed a residential soil dioxin cleanup guideline. This guideline is 1000 pg/g and relates only to 2,3,7,8-T_4CDD, the most toxic TCDD isomer. T_4CDD was not detected in 1992 in plots at the LSAG. Environmental contamination could still be a concern even if no T_4 dioxins or furans are present, if higher concentrations of P_5, H_6, H_7 and/or O_8 congeners are detected. At the national level in Canada, the Canadian Council of Ministers of the Environment has proposed a soil guideline of 1000 pg/g 2,3,7,8-T_4CDD toxic equivalent (TEQ).[2] The TEQ recognizes that dioxin and furan isomers vary considerably in their relative toxicities. Therefore, the TEQ system combines all the dioxin and furan data, weights their concentrations relative to their toxicity and produces a single number equivalent to the combined toxicity of all the dioxins and furans converted to the most toxic 2,3,7,8-T_4CDD isomer.

Table 3 illustrates the conversion of the dioxin and furan data from the LSAG from congener concentrations into TEQs. The highest total TEQ (21.3 pg/g - Site 194 in 1992) was about 2% of the Canadian Council of Ministers of the Environment TEQ guideline for residential/parkland soil.[2]

4. Conclusions.

The 1992 sampling of LSAG revealed that the incinerator ash piles have not had a measurable impact on the concentrations of inorganic elements in the soil. There has not been a significant change from the 1988 sampling nor was there consistent concentration gradient relative to distance and direction from the ash piles. These data do not support the conclusions of the report summarising the 1988 sampling, which concluded that marginal cadmium contamination may have occurred at garden plots closest to the ash piles. The 1992 data suggest that there has been no inorganic contamination of the LSAG.

Like the first sampling conducted in 1988, the 1992 data suggest the possibility that very marginal dioxin contamination has occurred, as dioxin concentrations were higher in both years at the garden plot closest to the ash piles. Because of the natural variability in dioxin and furan concentrations, it cannot be concluded that the differences seen between the two sampling years is real. However, the ratio of the various dioxin and furan congener groups in the incinerator ash is in marked contrast to the ratios in the soil at both sample sites and in both sample years. The ash contains relatively high concentrations of T_4CDD and very high concentrations of O_8CDD and T_4CDF. In contrast, none, or very low concentrations of both T_4CDD and T_4CDF and relatively low concentrations of O_8CDD were detected in the soil. In addition, the ash had a furan congener ratio of $T_4 > P_5 > H_7 > O_8 > H_6$, whereas the ratio of the furan congener groups in the soil was almost exactly opposite ($H_7 > O_8 > H_6 > P_5 > T_4$). Based on this data, it cannot be concluded that the incinerator ash was the source of the dioxins and furans in the soil from the LSAG, particularly since the LSAG concentrations were within the range encountered in Ontario background soil. Regardless of the source of the marginal dioxin and furan concentrations, the TEQs were only a fraction of the TEQ guideline. These data support the continued use of the LSAG for public vegetable gardeners. Even though contamination was not documented, the potential for contamination exists. Because of the proximity of the incinerator ash piles, ash could blow over the LSAG, or it could be transported via surface water runoff. The ash piles are large and the slopes are steep. Therefore, erosion from the piles into the vicinity of the LSAG is a potential source of future soil contamination. The establishment of a vegetation cover on the ash piles stablize the surfaces and slopes and would reduce the potential for off-site contamination through wind and water erosion.

5. References

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Table 1A. Concentrations * of inorganic elements in soil samples collected from the Leslie Street Allotment Gardens, Toronto, June, 1992 compared with the November, 1988 data.

Site** No.	Element									
	Copper		Nickel		Lead		Zinc		Silver	
	1992	1988	1992	1988	1992	1988	1992	1988	1992	1988
194	33	44	14	17	145	69	140	120	0.3	0.7
2	39	NR	19	NR	105	NR	150	NR	0.8	NR
243	13	13	9	8	31	34	53	52	0.4	0.1
151	21	26	12	13	69	73	87	94	0.4	0.3
69	28	34	15	17	73	79	100	118	0.7	0.4
54	35	39	17	16	83	114	125	133	0.8	0.6
9	64	NR	23	NR	145	NR	210	NR	2.8	NR
203	41	30	17	14	63	120	115	117	1.0	0.1
ULN	100		60		500		500		NG	

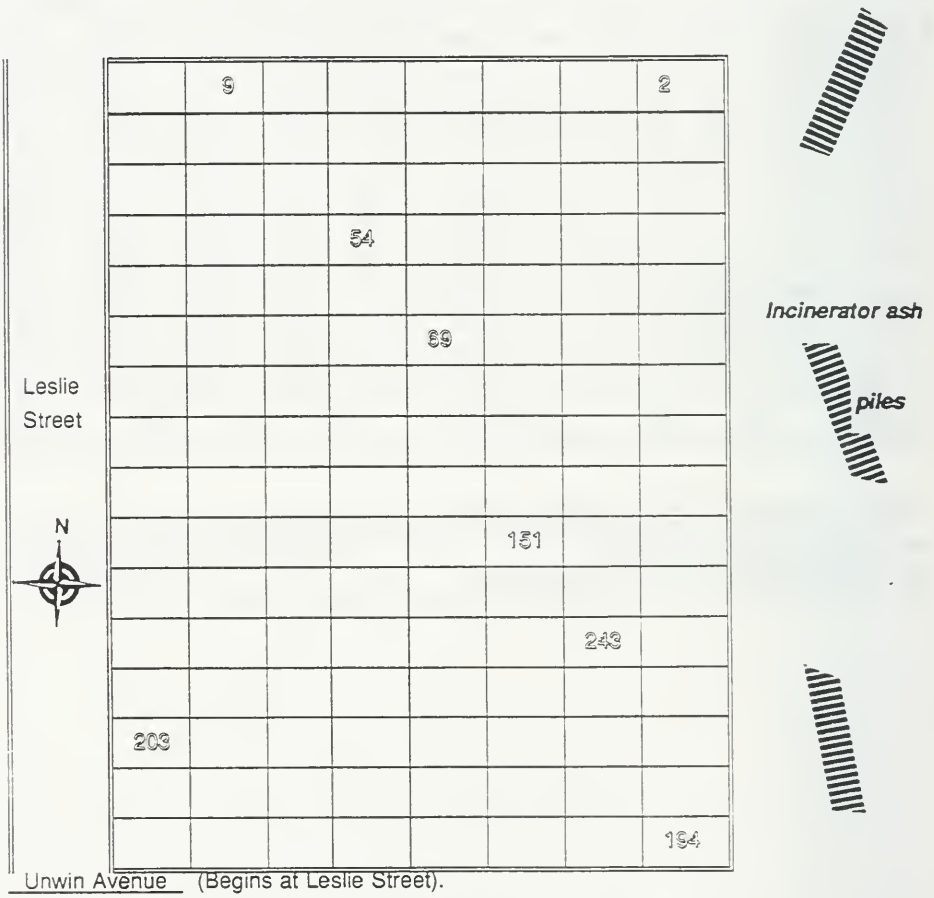
* ug/g, dry weight, mean of duplicate samples and analysis.
** - Site Nos. arranged in increasing distance from the ash pile (194 is closest).
NR - No results, Site not sampled in 1988.
NG - No guideline.
ULN - Phytotoxicology Upper Limit of Normal guidelines (see Appendix).

Table 1B. Concentrations * of inorganic elements in soil samples collected from the Leslie Street Allotment Gardens, Toronto, June, 1992 compared with the November, 1988 data.

Site** No.	Element									
	Arsenic		Cadmium		Mercury		Antimony		Selenium	
	1992	1988	1992	1988	1992	1988	1992	1988	1992	1988
194	3.8	3.0	0.7	3.5	0.06	0.09	1.2	0.53	0.6T	0.90
2	7.0	NR	1.1	NR	0.12	NR	0.9T	NR	0.9T	NR
243	2.3	2.4	0.5	0.6	0.04	0.05	0.3T	0.29	0.5T	1.40
151	2.5	2.1	0.6	0.9	0.09	0.09	0.9T	0.53	0.7T	0.93
69	3.1	3.2	0.8	1.1	0.06	0.04	0.7T	0.71	0.6T	1.13
54	6.3	4.4	0.9	1.1	0.09	0.09	0.9T	0.80	1.8	1.20
9	4.5	NR	2.1	NR	0.10	NR	1.4	NR	0.7T	NR
203	3.4	3.1	0.9	0.8	0.11	0.06	0.6T	0.95	1.5T	1.40
ULN	20		4		0.5		8		2	

* ug/g, dry weight, mean of duplicate samples and analysis.
** - Site Nos. arranged in increasing distance from the ash pile (194 is closest).
NR - No results, Site not sampled in 1988.
T - A measurable trace amount, interpret with caution.
ULN - Phytotoxicology Upper Limit of Normal guidelines (see Appendix).

Sketch Map Showing the location of the eight soil sample sites (2, 9, 54, 69, 151, 194, 203, and 243), Leslie Street Allotment Garden*, Toronto, June, 1992. (not to scale)



= Incinerator ash piles east of the garden.

* = Total area of allotment garden is 186 meters north to south and 60 meters east to west. Individual sites measured 8.5 meters x 3.3 meters.

SDB-047-3512-93.

Appendix

Derivation and Significance of the MOEE Phytotoxicology
"Upper Limits of Normal" Contaminant Guidelines.

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: *Ontario Ministry of the Environment. 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples. Phytotoxicology Section, Air Resources Branch: Technical Support Sections NE and NW Regions, Report No. ARB-138-88-Phyto. ISBN: 0-7729-5143-8.*). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall below the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.

SDB-047-3512-93.

Table 3. Calculation of 2,3,7,8-T_4CDD Toxic Equivalents (TEQ) for soil from Allotment Garden Sites 194 and 203 sampled June, 1992 and compared with the November, 1988 data.

Congener Group	% 2,3,7,8 Substituted	TEF	Site 194				Site 203			
			1992		1988		1992		1988	
			CONC.	TEQ	CONC.	TEQ	CONC.	TEQ	CONC.	TEQ
T_4CDD	5	1	DL	DL	61	3.05	DL	DL	DL	DL
P_5CDD	10	0.5	6	0.3	DL	DL	3	0.15	DL	DL
H_6CDD	30	0.1	89	2.67	75	2.25	18	0.54	30	0.9
H_7CDD	50	0.01	1100	5.5	1400	7.0	99	0.495	860	4.3
O_8CDD	100	0.001	3100	3.1	1800	1.8	250	0.25	880	0.88
T_4CDF	10	0.1	52	0.52	DL	DL	DL	DL	DL	DL
P_5CDF	15	0.5	63	4.725	DL	DL	6	0.45	DL	DL
H_6CDF	50	0.1	86	4.3	DL	DL	6	0.3	DL	DL
H_7CDF	50	0.01	140	0.07	DL	DL	18	0.09	38	0.19
O_8CDF	100	0.001	120	0.12	79	0.079	17	0.017	34	0.034
Total			4756	21.305	3415	14.179	417	2.292	1842	6.304
TEQ Guideline				1000		1000		1000		1000

Concentrations and TEQ expressed as pg/g, single samples.
DL - At or below analytical detection limit.
TEF - Toxic Equivalent Factor
TEQ - 2,3,7,8-T_4CDD Equivalents
TEQ Guideline - CCME residential/parkland 1000pg/g.

Table 2. Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in the Leslie Street Allotment Garden soil (depth 0-5 cm) collected June, 1992 compared with the November, 1988 data*.

Congener Group	Incinerator Ash	Site 194		Site 203	
		1992	1988	1992	1988
T_4CDD	420	DL	61	DL	DL
P_5CDD	110	6	DL	3	DL
H_6CDD	1300	89	75	18	30
H_7CDD	3400	1100	1400	99	860
O_8CDD	9800	3100	1800	250	880
Total PCDD	15030	4295	3336	370	1770
T_4CDF	2200	52	DL	DL	DL
P_5CDF	1000	63	DL	6	DL
H_6CDF	DL	86	DL	6	DL
H_7CDF	170	140	DL	18	38
O_8CDF	100	120	79	17	34
Total PCDF	3470	461	79	47	72

* - All concentrations expressed in pg/g (picograms per grams), single samples.
** - Plot 194 closest to the ash pile and plot 203 farthest from the ash pile.
Incinerator ash data provided by Central Region.
DL - At or below the detection limit (TCDD/TCDF is 2 pg/g).